

positions. Initially, I was hired as a Scientific Officer initially carrying out research into the synthesis of inorganic tin compounds. Subsequently I studied the ion exchange and heterogeneous catalytic properties of tin oxide. My responsibilities changed when I became a Division Manager -- first for the Tinsplate And Electrochemistry group and later adding the Metallurgy group to my watch. Finally for the year prior to leaving the Institute I held the role of Market Development Manager.

3. I left the Institute to join Multicore Solders Ltd., Hemel Hempstead, England where I held the position of International Technical Director from 1989 to 2000. In 2000, Henkel KGaA (now Henkel AG & Co. KGaA), Dusseldorf, Germany acquired Multicore. I remained with Henkel until my retirement in 2008. During my roughly eight years with Henkel I held various positions, including International Director, Soldering Materials Product Development, International Director, PCB Assembly Materials Product Development and International Business Director -- Circuit Protection And Thermal Interface Materials.

4. In my educational experience and my industrial experience, my work has involved either conducting metallurgical research and development activity or overseeing and managing the activity of others in this area. For instance, while at the Institute I was involved in the study of wetting behavior of

solder alloys and mechanical properties of solder alloys and joints made from solder alloys, including lead free solder alloys made from tin-silver, tin-copper, tin-zinc, tin-bismuth, and tin-antimony. And at Multicore (and later Henkel), I was involved in the investigation of the interplay between solder alloys of this type and flux vehicles, as well as the physical properties and integrity of solder joints made from such solder alloys. In particular, I participated in the UK Consortium Study of Lead Free Solder in 1991-93 and the European "IDEALS" Consortium in 1996-99 which is recognized as a benchmark study of Pb-free alternatives for the electronics industry. In 2001 I was a member of a UK Government study tour of Japan tasked with comparing Pb-free solder implementation research and experience in that country with equivalent activities in UK/Europe. Throughout this time and subsequently, I worked with original equipment manufacturers in the practical commercial application of such lead free solder alloys in consumer, industrial, and automotive electronics products.

5. Based on this experience, I am qualified to make this Declaration Under 37 C.F.R. § 1.132 in support of the subject application.

6. Thus, in order to draw my conclusion I studied the subject application, an Amendment dated April 27, 2010, an Office Action mailed July 22, 2010 and two U.S. patent documents -- U.S.

Patent Nos. 5,863,493 (Achari et al.) ("the '493 patent") in view of 5,538,686 (Chen et al.) ("the '686 patent"), cited in the Office Action. The Office Action alleges that the claims are rendered obvious by the '493 patent in view of the '686 patent. However, in my view, based on the teachings in those patent documents, neither one, individually or in combination, renders the claims as they are presently pending unpatentable.

7. I set forth a brief review of the invention described by the subject application, together with my understanding of the teachings of the cited U.S. patent documents, as one of ordinary skill in the art of metallurgy.

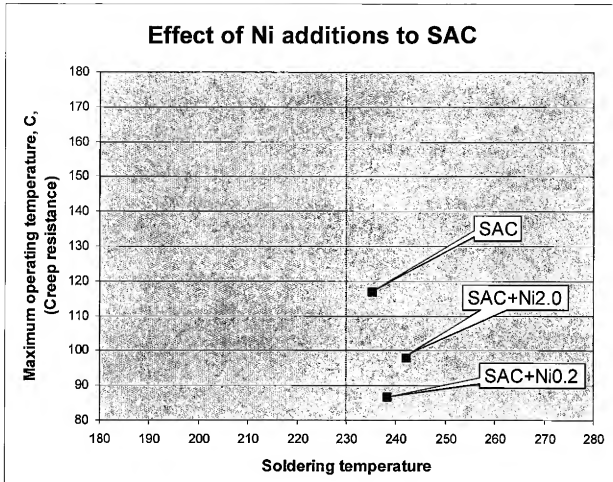
8. The present invention is defined for instance with reference to Claim 1. As so set forth, a lead free soldering material is provided, which consists essentially of Sn (tin), 10 wt.% or less Ag (silver), 10 wt.% or less Bi (bismuth), 1 to 3 wt.% Sb (antimony), 0.5 to 3 wt.% Cu (copper), and 1.0 wt.% or less Ni (nickel).

9. The first of the two U.S. patent documents cited as references against the pending claims is the '493 patent, which is directed to and claims an electrical solder composition consisting essentially of between 91.5-96.5% Sn; 2-5% Ag; 0-2% Cu; and 0.1-2% Ni and having a melting temperature 220°C or less. As reported in the '493 patent, Sn-Ni, Sn-Cu, and Sn-Cu-Ni alloys have a uniformly dispersed microstructure leading to

intermetallic formation. Such intermetallic formation is reported to *increase* resistance to temperature cycling. Interestingly, no creep, fatigue or even tensile or shear strength measurements are reported in the '493 patent.

10. The addition of Ni at two amounts within the range recited in the '493 patent has been determined independently to not increase resistance to temperature cycling in a $\text{SnAg}_{3.8}\text{Cu}_{0.7}$ alloy (referred to herein as "the SAC alloy"); rather, as measured by creep performance, the opposite has been reported as true. See Fig. 1 below, the data presented in which having been extracted and reproduced from the Final Report of BMBF Consortium Project entitled "Innolot", p. 34 (2004).

Fig. 1



11. The data presented in Fig. 1 was earlier presented in the figure shown at page 8 of the Amendment dated April 27, 2010. Fig. 1 shows the impact made on the SAC alloy by the introduction of one element (i.e., Ni), instead of the impact to the SAC alloy made by the various elements shown in the figure from that Amendment. Later figures in my Declaration will show the impact of some of those elements on the SAC alloy.

12. Thus, in Fig. 1, Ni at a level of 0.2% and 2.0% has been added to the SAC alloy, creating two solder alloys each

of whose maximum operating temperatures (or, creep resistance) has been dramatically reduced from that of the SAC alloy used as a base. Despite what the '493 patent suggests, the addition of Ni significantly *decreased* creep resistance.

13. Given the decrease in creep resistance versus SAC shown by the SnAgCuNi alloy of the '493 patent, one of ordinary skill in the art in my view would not have chosen such a SnAgCuNi alloy as a starting place.

14. The '686 patent, cited in the Office Action as a secondary reference, is directed to an article comprising a solder composition, the solder composition comprising an alloy having at least approximately 70 percent Sn, approximately 6-10 weight percent Zn, approximately 3-10 weight percent In, and an effective amount of Bi not greater than approximately 10 weight percent to reduce the tendency for the formation of lower temperature phases. Sb is mentioned as a possible alternative additional element. Thus, distilled to its essence, the '686 patent discloses a SnZnIn alloy, with Bi and possibly Sb.

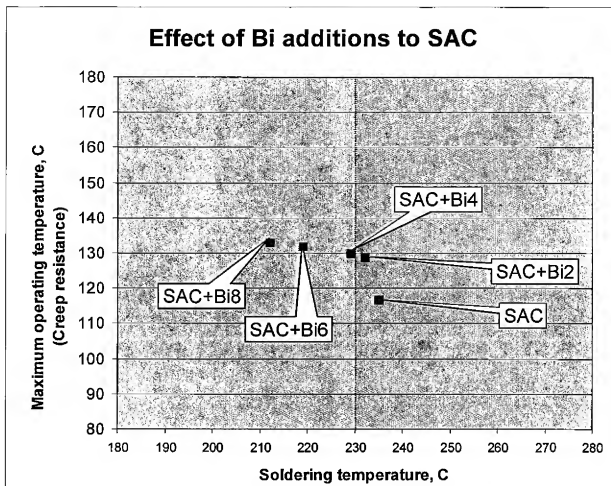
15. An alloy formed from Sn, Zn and In will show solid solution hardening in the Sn phase because both Zn and In have significant solid solubility in Sn (2.5% and 12% at the eutectic temperature) and differ in atomic size from Sn so that they distort the Sn crystal lattice. The Zn that does not go into solid solution forms a coarse Zn eutectic phase. The

strengthening mechanism in the SAC alloy involves the formation of the intermetallic phases, Ag_3Sn and Cu_6Sn_5 , giving a eutectic microstructure of essentially pure Sn with a fine dispersion of intermetallic particles. This results from the very low solid solubility in Sn (0.1% and 0.01% at the eutectic temperature) of both Ag and Cu in the SAC alloy.

16. The '686 patent reports that the addition of Bi (albeit to a SnZnIn alloy) reduces the formation of low melting phases. In practice, the addition of Bi to the SAC alloy introduces low melting phases. (See e.g. Fig. 2 below.) Consequently, in my view, the '686 patent does not disclose, teach or suggest anything about the influence of added Bi and Sb on the SAC alloy.

17. While the '686 patent does not add Bi to a SAC alloy (but rather to a SnZnIn one), for the sake of discussion I present some findings on the addition of Bi at four different amounts to a SAC alloy. Again, the data presented was extracted and reproduced from the Final Report of BMBF Consortium Project entitled "Innotot", p. 34 (2004). Reference to Fig. 2 below shows that the addition of Bi to a SAC alloy increased the creep resistance of the SAC alloy. Fig. 2 also takes data from the figure shown at page 8 of the Amendment dated April 27, 2010.

Fig. 2

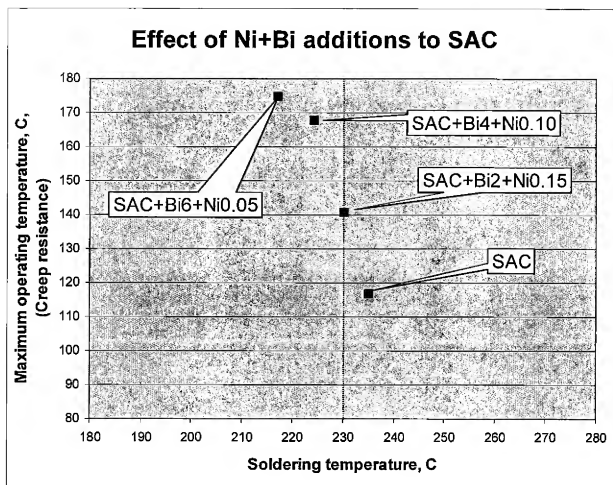


18. In Fig. 2, Bi at a level of 2%, 4%, 6% and 8% has been added to the SAC alloy, creating solder alloys each of whose soldering temperatures has been reduced relative to that of the SAC alloy. The low melting phases created are undesirable because they tend to reduce reliability in fatigue under temperature cycling.

19. Reference to Fig. 3 below shows the impact that

the combination of the addition of Ni and Bi has on the SAC alloy. Once again, the data presented was extracted and reproduced from the Final Report of BMBF Consortium Project entitled "InnoLot", p. 35 (2004). Fig. 3 also takes data from the upper figure shown at page 10 of the Amendment dated April 27, 2010. The data illustrates the significant increase in operating temperature (or, creep resistance) achieved by the addition of the combination of Ni and Bi. The effect of Ni on the SnAgCuBi alloy is not disclosed, taught or suggested by the '493 patent.

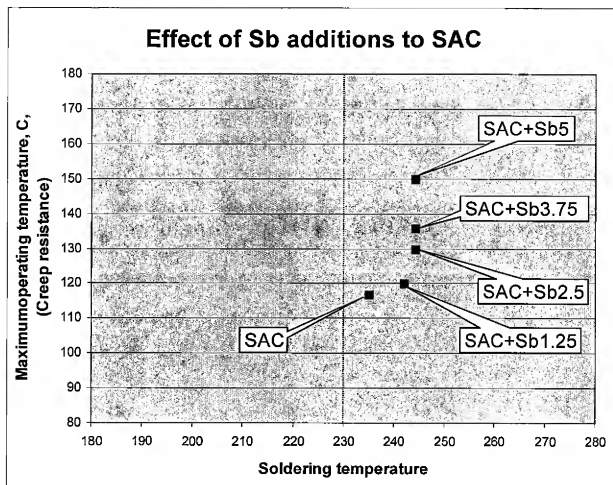
Fig. 3



20. Reference to Fig. 4 below shows the impact that the addition of Sb can have on the SAC alloy. Once again, the data presented was extracted and reproduced from the Final Report of BMBF Consortium Project entitled "Innolot", p. 34 (2004). The data was earlier presented in the figure at page 9 of the Amendment dated April 27, 2010. The data illustrates that the addition of Sb improves creep behavior in its own right. In

addition, there are no low melting phases in the SAC alloy due to the addition of Sb.

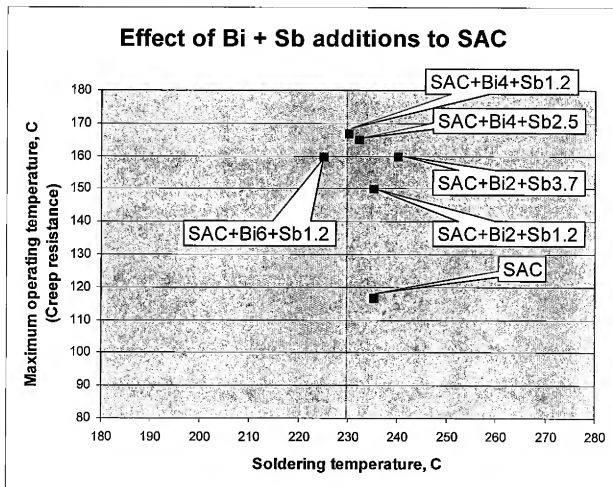
Fig. 4



21. Reference to Fig. 5 below shows the impact that the addition of the combination of Bi and Sb can have on the SAC alloy. Once again, the data presented was extracted and reproduced from the Final Report of BMBF Consortium Project entitled "Innolot", p. 36 (2004). The data was earlier presented

in the lower figure at page 10 of the Amendment dated April 27, 2010. The data illustrates that the addition of Sb to the SACBi alloy counters the effect of the Bi addition, which introduces low melting phases to the formed alloy.

Fig. 5



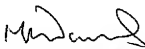
22. Turning back to the '493 patent and the '686 patent, the metallurgies of the two base alloy systems are distinctly different, leading to different behaviors and

different expectations. Consequently, in my view the '693 patent does not disclose, teach or suggest anything about the influence of added Bi and Sb on SAC alloy. As such, in my view one of ordinary skill in the art would not have been motivated to resort to such a teaching in the '686 patent in an effort to remedy the shortcomings of the solder alloy disclosed in the '493 patent.

23. Accordingly, in my view, the presently claimed invention is not rendered obvious over the combination of the '493 patent and the '686 patent cited in the Action.

24. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information or belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and like so made are punishable by fine or imprisonment or both under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated: 22/Nov/2019

By: 
Malcolm E. Warwick